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Assessment of Rain Water Harvesting Technologies for Improved Food Security in Kauwi Sub-Location, Kitui County.

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Abstract

The study aimed at studying the factors that influence the utilization of specific rainwater harvesting technologies in Kauwi sub-location, Kitui County. The study adopted a survey design. Random sampling was used to identify the villages and households systematically sampled to be interviewed. The target population was 1600 households, 10 per cent of the target population was obtained to get the representative sample size of 160. Kauwi Sub- Location was clustered into 23 villages and 50 per cent of the villages were then randomly selected for the purpose of the study. The results revealed that social-economic factors such as level of education, membership to farmers' group, access to credit, age, gender and the type of soil influenced the utilization of the technologies. Smallholder farmers need awareness of the various technologies in order to maximize on its utilization. The findings shall help farmers in prioritizing factors that influence decisions on utilizing technologies and policymakers in developing agricultural policies. The study recommended that the government should shift focus on more public participation rather than state involvement in awareness creation on investment of rainwater harvesting technologies in arid and semi-arid lands so as to increase acceptance of the technologies hence increase agricultural productivity thus improving food security. The households' heads should be educated about farmers groups and their importance in gaining information and its ability in enabling them to access credit hence will enable them in investing in various suitable and sustainable rainwater harvesting technologies.

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1.0 INTRODUCTION

Water is an essential natural resource, vital for any development to take place. However, studies indicate not more than one percent of the water is freely available for social needs including agricultural production in the entire world (Boretti & Rosa, 2019). FAO (2011) indicated that the demand for water had increased worldwide rapidly, causing a gap amid provision and fulfilling the various human needs, and real supply and access to best water quality, mostly in low to medium-income countries.

Arid and semi-arid regions (ASARs) worldwide are facing water scarcity challenges, mutually for drinking and for domestic, industrial, commercial and agricultural purposes. Rain-fed is the most common farming practice however; it has been challenged by aridity and the uncertain climate. Farmers are met by rainfall that is low on average annually and changing rainfall distribution both temporally and spatially (Luvai et al., 2014). In the arid and semi-arid areas of Kenya is characterized by insufficient water for household use and for crop and livestock production (Jaetzold et al., 2007).

Due to low rainfall and its irregularity and variability in distribution, low fertilizer use and poor overall crop management, smallholder farmers obtain very low yields on average (Jaetzold et al., 2007). The unreliable rainfall for agriculture results into food insecurity in the region. Quite a number of suggestions are being made by stakeholders relying on water for various purposes on how they can maximize production with minimum available water, (Jothiprakash & Sathe, 2009). A big population of people has shown interest and is participating in rainwater harvesting. Despite the known advantages about the rain water harvesting technologies, the community is utilizing them at a low rate than expected, hence the focus of the study on factors influencing the utilization of the technologies.

This study will generate information that will help farmers to ensure that decision they make on capitalizing on rain water harvesting technologies have been prioritized upon the factors. The information will act as guideline to the ministry of agriculture in formulating the strategies and policies in agriculture in rain water harvesting technologies. Additionally, policy makers will also benefit as they will use the information in developing policies and strategies to encourage community members to adopt rain water harvesting technologies. Finally, the study will add to the empirical literature relating to rain water harvesting thus increasing the acceptability of the study by the researchers in society

2.0 LITERATURE REVIEW

Siraj and Beyene, (2017) conducted a research in Gursum District in Ethiopia on the determinants of RWHT. The results showed that farming experience, education level of sampled household heads, family size, labor availability, mean land holding and external support were significant and had a

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positive potential relationship to adoption while distance to the market was negatively significant related to adoption since as distance to the market increased, access to necessary tools for construction of RWHT technologies reduced.

Teshome *et al*., (2015) conducted a detailed farm survey in three water sheds on the drivers of different stages on the adoption of soil and water conservation (SWC) technologies in the north-western highlands of Ethiopia. It was evident from results that some socio-economic and institutional factors affect the three adoption stages, initial, actual and final adoption stages of SWC in different ways. The labor used in the farm, the parcel size, the possessed tools, teachings in SWC, programs present in SWC, social capital, distribution of labor schemes and perception of erosion problems have an influence that is significant and positive on actual and final phases of adoption of SWC. Moreover, tenure security, cultivated sizes of land, slopes of the parcels and the perceptions of the importance of SWC related positively to the final step of adoption of SWC. They recommended to the policy makers that they needed to consider factors affecting adoption of SWC. These factors include; profitability, security of tenure, social capital, technical support, and resource endowments (e.g., tools and labor) while planning and implementing SWC policies and development programs.

Cheserek et al. (2013) in Keiyo district of Kenya examined the factors influencing farmers' decision to adopting rainwater harvesting techniques. The study found out that adoption rate by female headed households was low, those with high level of education that is above primary level have positive attitude toward adoption compared to those who had not attended school. Households with young household heads adopted rainwater harvesting technologies, they were enthusiastic about adopting the technology, financial endowment of rich and in between-income household motivated them to taking credit and spend in RWHT.

Members who belonged to a social institution were found to adopt RWHT as they could access information during group meetings about the technologies and its advantages. Households with positive perception on rain water harvesting were found to adopt the technology while those with undesirable perception avoided utilizing the technology. Among the factors that were found to negatively influence te utilization of RWHT were; poor endowment of both capital and human resource, lack of access to credit and negative perception.

3.0 RESULTS AND DISCUSSION

Influential Factors of the Utilization of Rain Water Harvesting Technologies in the Kauwi Sub-location

From the results in table 2, age significantly influenced the utilization of *Zai pits* ($p<0.05$, $B=-0.10$). A unit increase in age meant decrease in the odds of utilization of this technology. This was ascribed to the fact that, with increasing age, the people became less energetic. For technologies that needed much

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energy in its construction then meant that older people would shun away from such hence decreasing in odds of its utilization. On the contrary, education level ($p>1.0$, B=-0.33) and household size ($p>1.0$, B=-0.11) negatively influenced the utilization of this technology. It was expected that a unit increase in the level of education will help the people in learning about new technologies. Additionally, those with high education level are easily exposed to information that they can interpret enabling them to make informed decision. However, this was not the case with this study and was expected that those who were well educated had moved to urban areas in search of greener pastures of formal employment. This was in line with studies by Mangisoni et al. (2019) who found that more educated persons moved to urban areas in such of better employment. As the educated person move to urban areas, then household size becomes small. Smaller household size means that no labour is available for the construction of *zai* pits hence the decreasing odds in utilization of this technology with increase in household size.

Grass strips rain water harvesting technology was significantly influenced at 5 per cent significant level by occupation ($p<0.05$ and B=-0.48), type of soil ($p<0.05$ and B=-0.76) and state of land ($p<0.05$ and B=-0.78). It was expected that households who had formal employment are likely to utilize rain water harvesting technologies since they will invest the income they earn to these technologies. On the other hand, the income earned could be used in purchasing the food necessary which would be generated from the rain water harvesting technology hence needless in adapting to this technology. With formal employment, then there would be limited time in agricultural activity as most time would be spent in formal employment. This was in line with studies by Cheserek et al. 2013 who found that household heads with formal employment earned income from their employment which would be used for purchasing the needed needs. Virgin land negatively significantly influenced utilization of grass strip rain water harvesting technology. This could be attributed to the fact that this land was already well covered by grass and other natural vegetation hence no need for this technique since the technology is installed to help in controlling erosion. Muriu et al. 2017, found out that pasture land influenced utilization of this technology. This is because pasture was highly associated with animal fodder. Clay and loam soil negatively influenced the utilization of this technology. This could be attributed to the fact that the soils are sticky and could be are not influenced by erosion unless they are saturated. On the other hand, small holder farmers will prefer soils that are easy to rupture for the construction of rain water harvesting technologies. This study was in line with findings by Mekennon (2017) who found that farmers preferred constructing rain water harvesting technologies on sand soil which is easily ruptured during construction.

Trash line is simple technology that is traditionally practiced to reduce surface flow and control erosion Muriu et al. (2017). Soil type significantly influenced this technology at 1 per cent ($p<0.001$, B=-

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2.11). Trash line involved piling crop residues along contours in order to control erosion and help in improving water infiltrating into the soil. However, clay had high infiltration rate due to its high infiltration rate, no erosion would be experienced due to run off thus this negatively influenced utilization of trash lines in the study area. From the table 2, sand dam rain water harvesting technology was significantly influenced at 5 per cent level of significance by gender ($p<0.05$ and B=-1.95), land size ($p<0.05$ and B=-0.39) and 10 per cent level of significance by soil type ($P<0.01$ and B=-1.21). Male were less likely to utilize this technology. This was very much unexpected considering the fact that males have been assumed to be household heads that are associated with making final decisions at household level. This study was contrary to Mekonnen (2017) who found that male were the final decision makers at household level. A unit increase in land size reduced the probability of utilization of this technology. A unit increase in land size resulted in decreasing odds in utilization of sand dam RWHT. This could be attributed to the fact that households who had large parcels of land could grow diverse types of crops. Diversifying the crops increased their security since they believed that incase one crop failed then at least one of the many would not and would rely on it.

Those who had small parcels were likely to use this technology in order to maximize on it. This finding was in line with that by Mangisoni et al. (2019) who found that households with small parcels of land were more likely to utilize rain water harvesting technologies in order to make maximum use of their minimal available land. In this case, the technology was for communal use and farmers needed not to use it for personal use as it would result to conflicts. Clay type of soil negatively influenced the utilization of this technology. This soil type is difficult to rupture when compared to sand soil. Small holder farmers prefer the soil that easily ruptures for construction of rain water harvesting technologies. This finding was in line with that by Mekonnen (2017) who found out that small holder farmers preferred to install rain water harvesting technologies in soils that were easy to rupture on such as sand which had particles that are coarse and easy to dig into.

Earth dams was significantly influenced at 10 per cent significant level by soil type ($P<0.01$ and B=-2.14). Clay soil negatively influenced utilization of this technology. Farmers preferred soil that was easy to rupture during construction of the earth dams, in this case sand soil was highly preferred. This agreed with the study by Mekonnen (2017) that found farmers preferring soils that were easily to work on during construction of these technologies. Other factors that influenced utilization of this technology however, they were not significant included education level ($P>1.0$, B=0.33), title deed ($P>1.0$ and B=1.00) and access to credit ($P>1.0$ and B=2.57) positively influenced utilization of this technology. A unit increase in education resulted in an increase in the odds for utilization of the rain water harvesting technology. High education level meant more informed and aware households about the merits and demerits of this technology. This therefore enabled them households to make informed

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decisions. This finding was similar to findings by Tesfaye and Aziz (2013) who established education level to influence the utilization of rain water harvesting technologies significantly.

Access to credit increased the odds in utilizing this technology. This is because these households can take the risks associated with the utilization of the technology from their ability to access credit. They are not constraint financially and can purchase the needed inputs for the purpose of installing the technology. This agreed with studies by Ndunge et al. (2015) that found access to credit enables households to purchase inputs for installation of rain water harvesting technologies. Households who owned title deeds were more likely to utilize rain water harvesting technologies. This is attributed to the fact ha they are more secure with the project on such land. They believed that the projects would last for long and would not be disrupted to move out of the land in-case they did not have land ownership documents. This finding was in line with Lloyd (2015) who found small holder farmers who owned title deeds to more likely utilizing RWHT as they were secure with such projects on their own land.

Water pan rain water harvesting technology is labour intensive both during the initial and maintenance face. This was in line with the study by Makurira et al. (2007) who found that water pan needed high initial cost for construction especially in paying for labour needed during construction and the one needed during maintenance face. The factors that significantly influenced the utilization of this technology at 5 per cent significant level were, labour source ($p<0.05$, $B=1.42$) and the type of soil ($p<0.05$, $B=-1.05$). A unit increase in labour source increased the odds of utilizing water pan technology. During both the construction face and maintenance, this technology is greatly labour intensive. It requires a lot of labour. Households with more labour source are more likely to utilize this technology. This agreed with the findings by Mekonnen (2017) who found out that availability of labour made it easy for households to adopt rain water harvesting technologies. Clay type of soil negatively influenced utilization of water pan RWHT. This is because it is difficult to rupture on clay and loam relative to sand soil. Additionally, the time and cost of labour for rupturing sand type of soil is low relative to that of clay and loam. This finding was in line with that by Mekonnen (2017) where he found out that small holder farmers prefer sand type of soil as it is easy to rupture as well as relatively cheap labour is needed during construction compared to clay and loam.

Rooftop rain water harvesting technology was significantly influence at 5 per cent significant level by gender ($p<0.05$, $B=0.99$), household size ($p<0.05$, $B=0.16$) and type of soil ($p<0.05$, $B=-0.76$). It was very much unexpected that male was more likely to utilize this technology. Most female were responsible in utilizing rooftop rain water harvesting technologies as they were responsible in collecting water for domestic and livestock use. However, this could be due to the fact that the males were the decision makers and responsible for making various households' decisions. This finding was

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contrary to that of Ibrahim and Ibrahim (2013) who found females to be highly associated with rooftop rain water harvesting technology. A unit increase in household size increased the odds of utilizing this technology. The labour would be necessary where the storage for the rain water was not directly connected to the roof and the water was fetched as the rain fell and transferred to storage away from the roof. This study's finding was in line with that by Cheserek et al. (2013) who found out that labour source was significantly associated with utilization of the rain water harvesting technology.

Bore hole was statistically significantly influenced at 5% significant level by age ($p<0.05$, B=0.121), type of soil ($p<0.05$, B=-1.01) and state of land ($p<0.05$, B=1.57). A unit increase in age increased the likelihood of utilizing borehole. This is because older people were associated to have more experience in farming or have experienced crop failure due to low moisture in the soil. This finding was in line with studies by Mangisoni et al. (2019) who found out that older person have gained knowledge about advantage of utilizing rain water harvesting technologies and also learned about crop failures due to short seasonal rains. Clay type of soil negatively influences the utilization of boreholes as it was difficult to rupture into during construction of the technology. This was in line with studies by Mekonnen, 2017 who found that small holder farmers preferred sand type of soil that could easily rupture during the construction of the rain water harvesting technologies.

Trees aid in improving on ground water recharge and in soil conservation by avoiding soil erosion as it holds soil particles together (Jennie & Anders, 2016). Factors that significantly influenced the utilization of fruit trees at 5 per cent level of significance were labour source ($P<0.05$ and B= 0.73), land size ($P<0.05$ and B= 0.14) and the type of soil ($P<0.05$ and B= -0.88). A unit increase in labour source increased the odds of utilizing RWHT. Where both family and hired labour was involved there was an increase in the likelihood of utilizing the fruit tree rain water harvesting technology.

An initial stage was labour intensive and availability of labour influenced utilization of the technology. This was in line with studies by Llyod (2015) where he found that availability of labour influences the utilization of the rain water harvesting technologies. A unit increase in land size increased the likelihood of utilizing tree RWHT. This is ascribed to the fact that smallholder farmers with small parcels having not learned about the advantage s of trees and feel planting trees is not benefiting when compared to planting crops. Those with large parcels therefore will prefer to plant the trees since they can diversify with other crops on the large parcel.

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Table 2; Factors Influencing Utilization of Rain Water Harvesting Technologies

Outcome variables	Zai	Grassstrips	Trashlines	Sanddam	contour bunds	earthdam	waterpan	rooftop	**borehole**	**fruit tree**	exotic tree	indigenous tree
Sexhh	-1.990	0.550	0.093	-1.953*	-0.102	-1.978	-1.290	0.989*	1.115	0.261	-0.055	-0.824
Agehh	-0.098*	-0.017	-0.007	-0.030	-0.004	-0.077	0.000	0.012	0.121*	0.001	-0.022	-0.040*
Edlevelhh	-0.334	0.194	1.164+	-0.297	0.044	0.329	0.264	0.358	0.220	0.388	0.328	-0.327
Occuphh	0.160	-0.481*	-0.429	-0.181	0.026	0.172	-0.553	0.227	0.519	0.004	-0.222	-0.248
hhsize	-0.111	-0.062	0.076	-0.284+	0.066	0.105	0.058	0.155+	0.028+	0.064	0.007	-0.238**
labsource	0.608	-0.130	-1.143	0.663	0.093	1.341	1.417*	0.492	0.999	0.729*	0.440	1.646*
landsizehere	0.107	0.084	0.046	-0.393*	0.032	-0.011	0.030	0.068	0.016	0.135*	-0.072	0.246*
yrsfarming	0.057	-0.030	-0.016	0.036	-0.002	-0.047	0.004	-0.025	-0.023	-0.022	-0.001	0.029
typsoil	0.379	-0.761*	-2.105**	-1.214**	-0.666*	2.143*	-1.045*	-0.755*	-1.007*	-0.884*	-0.558*	0.159
statland	-0.099	-0.777*	0.156	-0.076	-0.149	0.346	0.235	0.113	1.569*	-0.300	0.480*	-0.800**
ttdeed	0.328	0.701	1.493	0.794	0.539	0.997	0.273	-0.343	0.435	0.209	0.553	-1.043*
offfarminc	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
accesscrdt	-1.251	0.398	0.315	-0.911	0.827+	2.573	0.435	-0.414	-1.559	0.319	-1.005*	0.257*
loanborrlastyr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	2.648	3.814*	1.044	7.052*	-0.341	-7.659	-1.177	-3.131+	-15.380**	0.005	0.672	5.514**
Hosmer and Lemeshow test(p-value)	0.623	0.817	0.471	0.597	0.529	0.953	0.947	0.152	0.953	0.034	0.956	0.472
Nagelkerke	0.293	0.286	0.443	0.375	0.12	0.494	0.219	0.192	0.354	0.25	0.265	0.349

*Significance values are as follows: 0 - 0.001 '***', 0.001 - 0.01 '**', 0.01 - 0.05 '*', 0.05 - 0.1 '+', 0.1 - 1.0 '' (no symbol), R Core Team (2017). Values in the table are the B odds.*

4.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions: The study found out that specific technologies were significantly influenced by different factors except for the type of soil that influenced all the selected rain water harvesting technologies. Based on the findings, it was evident that household size, labour source were the main factors that influenced utilization. Households with bigger population were more likely to utilize the technologies as well as those who had more labour. Bigger household meant more source of labour and small household size meant little labour source. Those with little labour source were likely to use hired labour in order to utilize the various rain water harvesting technologies. The findings also revealed that number of farming years highly related to the utilization of rain water harvesting technologies. This is because farmers who had been in farming for many years had more experience on crop failure due to water shortages hence knew the advantage of investing in rain water harvesting.

Recommendations: The government should shift focus on more public participation rather than state involvement in awareness creation on investment of rainwater harvesting technologies in arid and

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semi-arid lands so as to increase on acceptance of the technologies hence increase agricultural productivity thus improving on food security .The households' heads should be educated about farmers group and its importance in gaining information and its ability in enabling them to access credit hence will enable them in investing on various suitable and sustainable rain water harvesting technologies.

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